PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

PCT

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 9589WO/NW/MZ	FOR FURTHER ACTION See Form PCT/IPEA/416	
International application No. PCT/IB2004/004220	International filing date *(day/month/year)* 20-12-2004	Priority date *(day/month/year)* 22-12-2003
International Patent Classification (IPC) or national classification and IPC See Supplemental Box		
Applicant ABB AS et al		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of   6   sheets, including this cover sheet.

3. This report is also accompanied by ANNEXES, comprising:

   a. ☒ *(sent to the applicant and to the International Bureau)* a total of   8   sheets, as follows:

      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).

      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.

   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s))

      _____ , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

   ☒ Box No. I   Basis of the report

   ☐ Box No. II   Priority

   ☐ Box No. III   Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

   ☐ Box No. IV   Lack of unity of invention

   ☒ Box No. V   Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   ☐ Box No. VI   Certain documents cited

   ☐ Box No. VII   Certain defects in the international application

   ☐ Box No. VIII   Certain observations on the international application

Date of submission of the demand 22-07-2005	Date of completion of this report 01-12-2005
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM	Authorized officer Ender Dag /LR
Facsimile No. +46 8 667 72 88	Telephone No. +46 8 782 25 00

Form PCT/IPEA/409 (cover sheet) (April 2005)

Box No. I	Basis of the report

1. With regard to the **language**, this report is based on:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ ,
   which is the language of a translation furnished for the purposes of:

   > ☐ international search (Rules 12.3(a) and 23.1(b))
   >
   > ☐ publication of the international application (Rule 12.4(a))
   >
   > ☐ international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

   ☐ the international application as originally filed/furnished

   ☒ the description:

   > pages __1-21_____ as originally filed/furnished
   >
   > pages* _____ received by this Authority on _____
   >
   > pages* _____ received by this Authority on _____

   ☒ the claims:

   > pages _____ as originally filed/furnished
   >
   > pages* _____ as amended (together with any statement) under Article 19
   >
   > pages* __22-28_____ received by this Authority on __2005-11-14_____
   >
   > pages* __29_____ received by this Authority on __2005-11-23_____

   ☒ the drawings:

   > pages __1-6_____ as originally filed/furnished
   >
   > pages* _____ received by this Authority on _____
   >
   > pages* _____ received by this Authority on _____

   ☐ a sequence listing and/or any related table(s) – see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

   > ☐ the description, pages _____
   >
   > ☐ the claims, Nos. _____
   >
   > ☐ the drawings, sheets/figs _____
   >
   > ☐ the sequence listing *(specify)*: _____
   >
   > ☐ any table(s) related to the sequence listing *(specify)*: _____

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

   > ☐ the description, pages _____
   >
   > ☐ the claims, Nos. _____
   >
   > ☐ the drawings, sheets/figs _____
   >
   > ☐ the sequence listing *(specify)*: _____
   >
   > ☐ any table(s) related to the sequence listing *(specify)*: _____

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-41		YES
	Claims			NO
Inventive step (IS)	Claims	1-41		YES
	Claims			NO
Industrial applicability (IA)	Claims	1-41		YES
	Claims			NO

2. Citations and explanations (Rule 70.7)

Reference is made to the following documents:

D1: US 5204942 A
D2: US 2003050734 A1
D3: US 6347253 B1
D4: US 3654616 A

The applicant describes the problem of controlling the movements of one robot in coordinate with plurality of robots in a common workspace carrying a work on an object. To coordinate several robots to carry out pre-programmed tasks repeatedly quickly and accuracy is a complex arrangement. The system must constantly keep track and exchange of signals to avoid collisions between the robots. The intention of the applicant is to check the value within acceptable limits for a common reference value for a robot before the start of the next task execution. The control system provides a stop signal to the robot to wait for the procedure with next task when the value for the common reference is not within acceptable limits.

Document D1 discloses a robot control system (1) controlling plurality of robots (Ra-Rd) coordinated cooperative operation by a single control program. The control system controls a set of robots for cooperative operation by controlling the sequential execution of set unit motions for the robot. The control program includes task programs stored in a memory (2, 11), and communication instructions, such as STOP, START and WAIT, for communication to and between the coordinated robots. A reading/compiling unit (3, 12) reads and identifies the

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**

Continuation of: Cover sheet

B25J 9/16 (2006.01)
G05B 19/418 (2006.01)

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of: Box V

control of execution sequence of unit motion for each robot (see column 3, lines 17-68; figure 1-3, 6).

Document D2 discloses a control system for controlling plurality robots in a workspace. The control system is linked with the robots and position feedback sensor by commercially standard computer hardware and software for multiple applications. The system includes a program execution module (18) to selectively start and stop processing of the program of robot instructions and to generate a plurality of robot move commands. Activation signals and feedback signals are provided in the system to control execution of robot instructions (see [0027]-[0029], [0052]-[0056]; figure 1; abstract).

Document D3 discloses a control system used in a production shop made up of robots. A control system executes task instructions, comprising a higher-order module for making an inquiry as to whether or not a task instruction can be executed, and a lower-order module for determining whether or not the task instruction can be executed. The modules can be realized as either hardware or software (see column 4, lines 13-54; figures 1-4; abstract)

Document D4 discloses a programmable manipulator apparatus (24) with a series of six different pre-programmed task execution programs. Each program is arranged to position the manipulator arm of corresponding manipulator to a series of positions to a desired pattern of spot welds on a car body. The program selection of a desired program is made with signals from a sensing device (50), which indicates and presents particular car body to associated manipulator. The sensing device includes relay contacts (LR1-LR6) provided with start and stop pulses to permit selection of desired one of the six programs. An auxiliary control signal is recorded along with the program to sense the condition of movement of the manipulator arm in relation to task program, which can delay or regulate the task execution (see column 3, lines 7-32, column 5, lines 11-51, column 9, lines 16-53; figure 1-3).

The problem to be solved is to check a common reference value. If the reference value is not within acceptable limits a signal is provided to stop or wait of individual robot task before the start of the next task. The performance of task in

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of: Box V

progress will finish at the end of task execution and a provided command signal will hold next task execution on a temporary pause. After finishing execution of task in progress the process will continue from where it was paused last time. This improves the specific robot within the coordination of several robots to carry out next coming task right after the temporary stop or wait is taken place. Each individual robot will not necessary check its position in relation to a home reference position in order to continue. D1-D4 shows a control system to give instructions to several interacted robots with a computer including proper software. The instruction is handled by the computer and refers to signals in the system for which to avoid collisions or other unexpected damages. None of the indicated documents refer the control application of separate robot, based on a common reference, provide a temporary pause after end of present task in progress and to continue task execution from the position where a stop or wait is applied.

The problem to be solved in D1-D4 does not address the same problem to be solved in the claimed invention. D1-D4 describes how to coordinate several robots without interference of task within a work cell.

The problem of the claimed invention is to compensate for and to prevent each robot to individually check or re-position in relation to a known home reference position after a stop in a production line. The control of the application is checked with a common reference value within acceptable limits. The result will indicate to either a temporary stop or wait, or to continue as predetermined without problems related to any temporary stop or wait. The control system will provide a command signal to finish task in progress and wait before the start of the next task. This improves the continuous flow of the system after a stop or wait has taken place. Each robot will continue task execution normally with interpretation as if nothing wrong occurred; only a brake to wait for the coordinated robot to catch up its own task execution.

Hence it is not obvious for a person skilled in the art to modify D1-D4 to solve the same problem as referred to in the claimed invention.

The invention according to claims 1-41 is novel, industrial applicable and is considered to involve an inventive step.

CLAIMS

1. A method for controlling a robot in an application
comprising a plurality of robots (33a-n) carrying out an
operation on one or more work objects (39) in a common

5   workspace, wherein instructions for a plurality of movements
are recorded in a program controlling said robot,
characterised by controlling said robot dependent upon whether
said robot or any other robot in the common workspace is
proceeding as predetermined, according to a sensed or measured

10 common reference value (43', 64, 74), or not,
-checking (42, 61, 71) a value for a common reference for said
robot before the start of the next task,
-providing a signal (47, 47b, 62, 72) to said robot to stop
and wait (43, 64, 74) at the end of the present task if the

15 common reference value is not within acceptable limits.

2. A method according to claim 1, **characterised** by
-determining said plurality of movements as a plurality of
tasks,

20 -checking (42, 61) a value for a position reference for said
robot before the start of the next task,
-providing a signal to said robot to stop and wait (44b, 64)
at the end of the present task if the position reference value
is not within acceptable limits.

25
3. A method according to any of claims 1-2, **characterised** by
-checking (44b, 71) a reference value (64) or other
operational status for at least one other robot of said
plurality of robots (33a-n), and

30 -providing a signal to stop and wait (74) at the end of the
present task if at least one other robot has a status of
waiting or stopped.

AMENDED SHEET

4. A method according to claim 3, **characterised** by determining
the value of the position reference for the first said robot
by:
-sampling an output of a sensor member (92) arranged for
5   measuring a position of a target located on one of said one or
more work objects,
-comparing the measured position of the target to a
predetermined target position,
-registering, if the measured target position is not within
10   acceptable limits, the status of the position reference as not
acceptable.

5. A method according to claim 4, **characterised** in that the
target position on the work object is recorded for the
15   beginning of each task in said plurality of movements recorded
in said program and saved in an array or other memory storage.

6. A method according to claim 5, **characterised** by adjusting,
by means of a program editing application, the target position
20   of the work object after the first recording dependent on a
manual comparison.

7. A method according to claim 6, **characterised** by adjusting,
by means of a program editing application, the target position
25   of the work object after the first recording dependent on a
graphical comparison carried out using the program editing
application.

8. A method according to claim 1, **characterised** by setting an
30   indicator for a common reference in a program for any of said
robot of said plurality of robots to a status of **not**
acceptable or flag high (44b, 64, 74) which such common
reference indicator status is detectable by other controllers
or robot controllers.

35

AMENDED SHEET

9. A method according to any of claims 1-3, **characterised** by setting an indicator in a program for first said robot to a status of not acceptable or flag high, which such indicator status is detectable by other controllers or robot
5   controllers.

10. A method according to claim 8 or 9, **characterised** by re-setting the indicator in a program or the program for first said robot and thus removing the not acceptable status.
10

11. A method according to claim 8 or 9, **characterised** by re-setting the indicator in a program or the program for first said robot from not acceptable to acceptable, which such indicator status is detectable by other controllers or robot
15   controllers.

12. A method according to claim 1, **characterised** in that the common reference is based on any of the list of: movement of a transport member of a work object, a time period, a time
20   stamp, a measure of task completion, a measure of job completion.

13. A method according to any of claims 1-4, **characterised** in that the position reference value for the first robot is
25   checked at a time just before the first robot shall proceed to a subsequent task.

14. A method according to claim 13, **characterised** in that a reference value (64, 74) for the any of said plurality of
30   robots is checked according to a configured time value dependent on a Movement Program (21, 85) for the first robot.

15. A method according claim 14, **characterised** in that the reference value (64, 74) for the any of said plurality of
35   robots is checked according to a configured time value of the

Movement Program for the first robot dependent on a task or movement carried out by any other one of said plurality of robots (33a-n).

5   16. A method according to claim 4, **characterised** in that the measured position of said target is a current position.

17. A method according to claim 4, **characterised** in that the measured position of said target is, in part, a calculated
10 position.

18. A method according to claim 1, **characterised** by a robot controller determining that the common reference value measured or sensed (92, 93) is lower than the stored value,
15 and making the robot wait until the reference value is larger than or equal to the stored reference before continuing.

19. A method according to claim 1, **characterised** by a robot controller determining that the common reference value
20 measured or sensed (92, 93) is higher than the stored reference value, sending a signal to the external reference controller and/ or time keeper that a robot so controlled is late and the conveyor should be halted or the time reference stopped until the robot has caught up and attained an
25 acceptable reference value.

20. A method according to any previous claim, **characterised** in that the acceptable values for the reference value comprise a pre-set window with configurable tolerance limits.
30
21. A control device (81) for controlling a robot in an application comprising a plurality of robots, operating on one or more work objects in a common workspace, **characterised** in that said control device (81) comprises:

-a program member (85, 85a) for determining or detecting a
value for a common reference (43) for said robot before the
start of the next task,

-a logic member (85) for making, if the measured target

5   position is not acceptable, a decision that the robot shall
stop and wait,

-an output member (82) arranged capable to provide a signal to
said robot comprising an instruction to wait, and a program
member (86) for determining or detecting a value for a

10   position reference (64) for said robot before the start of the
next task.

22. A control device according to claim 21, **characterised** by
comprising program member (87) for determining or detecting a

15   value of a reference (74) for at least one other robot of said
plurality of robots (33a-n), before the start of the next task.

23. A control device according to claim 21, **characterised** by
comprising a processor member (83).

20

24. A control device according to claim 21, **characterised** by
comprising at least one memory storage member (84, 89).

25. A control device according to claim 21, **characterised** by

25   comprising one or more software members (86, 87, 85, 85a) for
carrying out the steps of a method according to any of claims
1-20.

26. A control device according to claim 25, **characterised** in

30   that at least one of the one or more software members is
arranged to check a time reference value for any of the one or
more robots.

27. A control device according to claim 25, **characterised** in

35   that that at least one of the one or more software members is

stored at least in part in the memory storage member of a
control device.

28. A control device according to claim 27, **characterised** in
that at least one of the one or more software members (85a,
86, 87) is stored, at least in part, in a memory storage means
of a cell controller (31) or other robot control system.

29. A control device according to any of claims 21-28,
characterised by comprising an I/O interface for wireless
communication with at least one sensor and/or member of at
least one robot.

30. A control system for controlling one or more robots in an
application comprising a plurality of robots operating on one
or more work objects in a common workspace, comprising a
computer or processor and memory storage means, and one or
more robot controllers (81), **characterised** by comprising:
-at least one robot controller (81) arranged capable to check
a reference value (43, 64, 74) for any of said plurality of
robots (33a-n), comprising
-a program member (85, 85a) for determining or detecting a
value for a common reference (43) for said robot before the
start of the next task,
-a logic member (85) for making, if the measured target
position is not acceptable, a decision that the robot shall
stop and wait,
-an output member (82) arranged capable to provide a signal to
said robot comprising an instruction to wait, and a program
member (86) for determining or detecting a value for a
position reference (64) for said robot before the start of the
next task.

31. A control system according to claim 30, **characterised** in that the system is arranged with sensor members (92) to measure a position (41) of the one or more work objects and/or transport members for said work objects and/or a clock of time

5   sensor (93) to measure elapsed time relative the one or more work objects and/or transport members for said work objects.

32. A control system according to claim 31, **characterised** in that the sensor members are arranged to provide a measurement

10 of the position of a work object that at least one of said plurality of robots shall operate on at the start of a task in a operating cycle or robot movement program (21).

33. A control system according to claim 32, **characterised** by a

15 graphical user interface arranged to display and carry out actions in respect of at least one robot controller (81) or cell controller (31) controlling said plurality of robots by means of a movement program (21, 85, 85a) including tasks comprising one or more movements.

20

34. A control system according to claim 30, **characterised** in that a control member of the at least one robot controller is arranged to check a time reference value for at least one of said plurality of robots.

25

35. A computer program comprising computer code means and/or software code portions for making a computer or processor perform any of the steps of claims 1-19.

30 36. A computer readable medium comprising the computer program according to claim 35 recorded on it.

37. A computer program product comprising the computer program according to claim 35 comprised in one or more computer

35 readable media.

AMENDED SHEET

38. Use of a control device according to any of claims 21-29 for a operating a robot together with at least one other robot or in an application to paint any of the list of: car bodies, car parts, vehicle sub-systems.

5

39. Use of a control device according to any of claims 21-29 for a operating a robot or automation application (1) to carry out an operation comprising any from the list of: coating, welding, riveting, gluing, fettling, folding plate, cutting,

10 bending plate, hemming plate, gripping an object, manipulating an object, stacking, pick and place.

40. Use of a control system according to any of claims 30-34 for a operating a robot or automation application (1)

15 in an industrial or commercial installation including any installation for mining, chemical manufacturing or processing, power generation or transmission and distribution, oil or gas exploration, oil refining.

20 41. Use of a control system according to any of claims 30-34 for teaching and/or programming and/or verifying a program for at least one robot in an application comprising a plurality of robots (33a-n) for carrying out an operation on one or more work objects in a common workspace to carry out an operation

25 comprising any from the list of: painting, coating, welding, riveting, gluing, fettling, cutting, folding plate, bending plate, hemming plate, gripping an object, manipulating an object, stacking, pick and place.

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AMENDED SHEET